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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 627558

2. To: (Receiving Organization) R.J. Thomas/N1E10000/WAVS		3. From: (Originating Organization) S.D. Ellingson/SF840000/MECH/HVAC		4. Related EDT No.: N/A	
5. Proj./Prog./Dept./Div.: Nuclear Material Stabilization		6. Design Authority/Design Agent/Cog. Engr.: R.Thomas/S.Ellingson/R.Thomas		7. Purchase Order No.: N/A	
8. Originator Remarks: This EDT releases initial support analysis for the 236-Z/291-Z Sample Vacuum System cross-tie effort. The attached analysis evaluates pressure drop considerations for potential line sizes.				9. Equip./Component No.: N/A	
				10. System/Bldg./Facility: 23A/234-5Z/PFP	
				12. Major Assem. Dwg. No.: N/A	
				13. Permt/Permt Application No.: N/A	
11. Receiver Remarks: N/A		11A. Design Baseline Document? ☒ Yes ☐ No		14. Required Response Date: N/A	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-6328		0	Pressure Drop Analysis	N/A	2	1	1

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)										
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date (M) MSIN
2	1	Design Authority	R.J. Thomas	5/11/00	T4-20	3		RN Anderson		T5-02
2	1	Design Agent	S.D. Ellingson	5/5/00	T4-20	3		Central Files		B1-07
2	1	Cog. Eng.	R.J. Thomas	5/11/00	T4-20					
2	1	Cog. Mgr.	R.A. Burk	5/11/00	T4-20					
		QA								
		Safety								
		Env.								

18. Signature of EDT Originator <i>S.D. Ellingson</i> Date: 5/5/00		19. Authorized Representative for Receiving Organization N/A Date:		20. Design Authority/Cognizant Manager <i>R.A. Burk</i> Date: 5/11/00		21. DOE APPROVAL (If required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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236-Z/291-Z Vacuum Pump System Pressure Drop Analysis For Line Size Selection

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC05-86RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

236-Z/291-Z Vacuum Pump System Pressure Drop Analysis For Line Size Selection

SD Ellingson
Fluor Hanford

Date Published
May 2000

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

Release Approval Date 5/5/00

Release Stamp

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Total Pages: 17

Fluor Federal Services	CALCULATION IDENTIFICATION AND INDEX	Calc. No.: 5204-22-M-002 <i>Pg 1</i>
		T.O./Job No.: 5204/R22
		Date: 10/20/99

Status and description of the attached Calculation Sheets.

Discipline: Mechanical

Project No. & Title: Plutonium Finishing Plant Contract 5204, Release 22

Calculations: 236-Z/291-Z Vacuum Pump System Pressure Drop Analysis

These calculations apply to:

Drawing No. _____

Rev. No. _____

Drawing No. _____

Rev. No. _____

Other (Study, CDR) _____

Rev. No. _____

The status of these calculations is:

☒ Final Calculations

☐ Void Calculations (reason voided): _____

Were calculations incorporated into the final drawings?

☐ Yes

☐ No

Were calculations verified by independent "check" calculations?

☐ Yes

☐ No

Original and Revised Calculation Approvals

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	<i>Jim Brown</i> 5/1/00		
Checked By	<i>BE. B. White</i> 5/2/00		
Approved By	<i>CR Jool</i> 5/3/00		
Checked Against			
Approved Vendor Data			

INDEX

Calculation Sheet
Page No.

Description

<u>1</u>	<u>Analysis "Given/Required/Solution"</u>
<u>2 thru 10</u>	<u>Pressure Drop Calculations</u>
<u>A1 thru A4</u>	<u>Appendix</u>
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

FLUOR ~~DANIEL NORTHWEST~~

DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 1 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-Z/291-Z VACUUM PUMP SYS.

Originated By S. D. ELLUM

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By DEB

Date 5/1/00

Location PFP COMPLEX, 200W

Revised By

Date

GIVEN THERE ARE CURRENTLY TWO SAMPLE VACUUM PUMP SYSTEMS AT THE PFP FACILITY FOR OBTAINING RECORD SAMPLES AND AIR MONITORING, ONE PUMP SYSTEM, THE PRF SYSTEM, IS LOCATED IN 236-Z AND SERVICES ONLY 236-Z. THE SECOND SYSTEM, THE PFP SYSTEM, IS LOCATED IN 291-Z AND SERVICES THE 291-Z, 232-Z, 2736-Z AND 234-5Z SYSTEMS. IT HAS BEEN REQUESTED TO COMBINE THE PRF SYSTEM WITH THE PFP SYSTEM AND ELIMINATE THE PRF VACUUM PUMPS. FOUR PIPING OPTIONS TO ACHIEVE THIS GOAL HAVE BE DETERMINED. SEE APPENDIX SHEETS A1-A4.

SYSTEM FLOW REQUIREMENTS FOR THE PRF SYSTEM HAS BEEN DETERMINED TO BE 196 CFM AT 17 IN Hg VACUUM. REF HNF-6327.

FOR PIPING DRAWINGS, SEE THE FOLLOWING:

H-2-29645, 29648, 29651, 29657, 29658 AND 29659.

REQUIRED DETERMINE THE INHERENT PRESSURE DROP OF EACH NEW SYSTEM OPTION. DETERMINE PRESSURE DROP FOR OTHER LINE SIZES TO ASSIST IN FINAL LINE SIZE SELECTION.

SOLUTION THE EQUATIONS AND TABLES IN CRANE FLOW OF FLUIDS, TECHNICAL PAPER No. 410, 19TH PRINTING, 1980 EDITION, WILL BE USED TO SOLVE THIS PROBLEM. UNLESS OTHERWISE NOTED, ALL REFERENCES MADE WITHIN THIS ANALYSIS ARE WITH RESPECT TO THIS PUBLICATION. THE BASIC DARCY FORMULA TO BE USED: $\Delta P = \frac{3.62 K \rho Q^2}{d^5}$

SYSTEM PARAMETERS & REFERENCES:

CRANE EQ 3-14

FLUID = AIR @ 68°F AND 17 IN Hg VACUUM

Q = FLOWRATE = 196 CFM = 3.267 FT³/SEC

P = WEIGHT DENSITY = .0752 LB_m/FT³ @ 14.7 PSIA = .0322 LB_m/FT³ @ 17 IN Hg VAC

d_6 = 6.065 IN

d_4 = 4.026 IN

d_2 = 2.067 IN

} INTERNAL PIPE DIAMETERS

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 2 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYS.

Originated By S.D. Egan

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By B. Bidini

Date 5/1/00

Location PFP COMPLEX, 200W

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FOR OPTION #1

THE INTENT OF OPTION #1 IS TO USE ONE OR MORE EXISTING 2" PIPELINES RUNNING BETWEEN BUILDINGS 236-2 AND 291-2. TO SIMPLIFY CALCULATIONS, EVALUATE THE NEW PIPING FROM THE EXISTING PIPING SEPARATELY AND CONSIDER 2", 4" & 6" PIPE SIZE OPTIONS. ALSO ASSUME THE HEPA FILTER ΔP IS CONSTANT AND ADD SEPARATELY.

$$\text{TOTAL } \Delta P = \Delta P (\text{NEW PIPING}) + \Delta P (\text{EXISTING PIPING}) + \Delta P \text{ FILTER}$$

- FOR NEW 6" PIPING, DETERMINE ΣK AND ΔP , FROM DRAWING REVIEW COMPONENTS INCLUDE 52 FT OF PIPE AND (8) 90° ELBOWS: NOTE, ASSUME NEW PIPING IS SAME AS EXISTING, IE, PIPE CODE M7, H-2-31750

$$K(\text{PIPE}) = \frac{fL}{D} \text{ CRANE 3-15, ASSUME TURBULENT FLOW } f = 0.015 \text{ CRANE A-26}$$

$$K(\text{PIPE}) = \frac{(0.015)(52)(12)}{6.065} = 1.543$$

$$K(\text{ELBOW}) = \text{QTY } 14 \text{ ft CRANE A-29, ASSUME } \frac{1}{4} = 1.5 \text{ f BUTTWELD FITTING}$$

$$K(\text{ELBOW}) = (8)(14)(0.015) = 1.68$$

$$\Sigma K = 1.543 + 1.68 = 3.223$$

$$\Delta P_{6"} = 3.62 \frac{\Sigma K Q^2}{d^5} = \frac{(3.62)(3.223)(0.0322)(3.267)^2}{(6.065)^5} = .00296 \text{ PSI} = .00603 \text{ IN H}_2\text{O}$$

- FOR NEW 4" PIPING, SAME FLOW AND FITTINGS ONLY DIFFERENT SIZE. FIND ΣK AND ΔP :

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(0.017)(52)(12)}{4.026} = 2.634$$

$$\Sigma K = 2.634 + 1.904 = 4.538$$

$$K(\text{ELBOW}) = \text{QTY } 14 \text{ ft} = (8)(14)(0.017) = 1.904$$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 3 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-Z VACUUM PUMP SYS.

Originated By S.D. ELLUM

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By BE Bullock

Date 5/1/00

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Revised By

Date

$$\Delta P_4'' = \frac{3.62 \text{ EK} P^2}{d^4} = \frac{(3.62)(4.538)(.0322)(3.267)^2}{(4.026)^4} = .02148 \text{ PSI} = \Delta P_4'' = .04374 \text{ IN Hg}$$

- TRY NEW 2" PIPING, SAME FLOW AND FITTINGS, FIND EK AND ΔP:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.019)(52)(12)}{2.067} = 5.735 \quad \sum K = 5.735 + 2.128 = 7.863$$

$$K(\text{ELBOW}) = \text{QTY } 14 \text{ ft} = (8)(14)(.019) = 2.128$$

$$\Delta P_2'' = \frac{3.62 \text{ EK} P^2}{d^4} = \frac{(3.62)(7.863)(.0322)(3.267)^2}{(2.067)^4} = .53590 \text{ PSI} = \Delta P_2'' = 1.09101 \text{ IN Hg}$$

- FOR THE EXISTING 2" PIPING, COMPONENTS INCLUDE → 145' 2"-SCH 90 PIPE
DETERMINE ΔP IF ALL (3) EXISTING PIPES ARE EMPLOYED: (3) 2" 90° ELBOWS
(3) 2" TEE, THRU FLOW
(1) 2" ENTRANCE
(1) 2" EXIT

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.019)(145)(12)}{2.067} = 15.994$$

$$K(\text{ELBOW}) = \text{QTY } 14 \text{ ft} = (3)(14)(.019) = .798$$

$$\text{FLOW} = \frac{Q}{3} = \frac{3.267}{3} = 1.089 \text{ CFM}$$

$$K(\text{TEE}) = \text{QTY } 20 \text{ ft CRANE A-29, } K = (3)(20)(.019) = 1.14$$

$$K(\text{ENTR}) = \text{QTY } (.5) \text{ CRANE A-29, } K = (1)(.5) = .5$$

$$K(\text{EXIT}) = \text{QTY } (1) = (1)(1) = 1$$

$$\sum K = 15.994 + .798 + 1.14 + .5 + 1 = 19.432$$

$$\Delta P_{(3)} = \frac{3.62 \text{ EK} P(\frac{Q}{3})^2}{d^4} = \frac{(3.62)(19.432)(.0322)(1.089)^2}{(2.067)^4} = .14715 \text{ PSI} = \Delta P_{(3)} = .29958 \text{ IN Hg}$$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 4 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYS

Originated By S.D. ECU

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By BE Bilih

Date 5/1/00

Location PFP COMPLEX, 200 W

Revised By

Date

- DETERMINE ΔP IF ONLY (2) OF THE (3) EXISTING PIPES ARE EMPLOYED:

COMPONENTS AND ϵK AS BEFORE, FLOW = $\frac{Q}{2} = \frac{3.267}{2} = 1.6335$

$$\Delta P_{(2)} = (\Delta P_{(3)}) \left(\frac{Q_{(2)}}{Q_{(3)}} \right)^2 = (.29958) \left(\frac{1.6335}{1.089} \right)^2 = .67405 \text{ IN Hg}$$

$\Delta P_{(2)}$

- DETERMINE ΔP IF ONLY (1) OF THE (3) EXISTING PIPES ARE EMPLOYED:

AS BEFORE WITH FLOW = $\frac{Q}{1} = Q$

$$\Delta P_{(1)} = (\Delta P_{(3)}) \left(\frac{Q_{(1)}}{Q_{(3)}} \right)^2 = (.29958) \left(\frac{3.267}{1.089} \right)^2 = 2.69622 \text{ IN Hg}$$

$\Delta P_{(1)}$

- FOR HEPA FILTER PRESSURE DROP, ASSUME CONSTANT @ 4 IN H₂O:

$$\Delta P_{(\text{FILTER})} = .29368 \text{ IN Hg}$$

OPTION #1 SUMMARY:

* IF NEW PIPING IS 6", INHERENT $\Delta P = .00603 \text{ IN Hg}$

IF NEW PIPING IS 4", INHERENT $\Delta P = .04374 \text{ IN Hg}$

★ IF NEW PIPING IS 2", INHERENT $\Delta P = 1.09101 \text{ IN Hg}$

* IF (3) EXISTING 2" LINES ARE EMPLOYED, INHERENT $\Delta P = .29958 \text{ IN Hg}$

IF (2) EXISTING 2" LINES ARE EMPLOYED, INHERENT $\Delta P = .67405 \text{ IN Hg}$

★ IF (1) EXISTING 2" LINE IS EMPLOYED, INHERENT $\Delta P = 2.69622 \text{ IN Hg}$

FILTER $\Delta P = .29368 \text{ IN Hg}$

* BEST CASE TOTAL = $.00603 + .29958 + .29368 = .59929 \text{ IN Hg}$

★ WORST CASE TOTAL = $1.09101 + 2.69622 + .29368 = 4.08091 \text{ IN Hg}$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 5 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYSTEM

Originated By S.D. ELLIOTT

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By BEB

Date 5/1/00

Location PFP COMPLEX, 200W

Revised By

Date

OPTION #2

OPTION #2 EMPLOYES ALL NEW PIPE AND FITTINGS. DETERMINE ΣK AND ΔP FOR PIPE SIZES 6", 4" & 2" RESPECTIVELY. SYSTEM COMPONENTS INCLUDE 297 FT OF PIPE AND (12) 90° ELBOWS.

• FOR 6" PIPE:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(0.015)(297)(12)}{6.065} = 8.814$$

$$\Sigma K = 8.814 + 2.52 = 11.334$$

$$K(\text{ELBOW}) = \text{QTY } 14 f = (12)(14)(0.015) = 2.52$$

$$\Delta P_6'' = \frac{3.62 \Sigma K f g^2}{d^4} = \frac{(3.62)(11.334)(0.0322)(3.267)^2}{(6.065)^4} = .61042 \text{ PSI} = .02121 \text{ IN Hg}$$

• FOR 4" PIPE:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(0.017)(297)(12)}{4.026} = 15.049$$

$$\Sigma K = 15.049 + 2.856 = 17.905$$

$$K(\text{ELBOW}) = \text{QTY } 14 f = (12)(14)(0.017) = 2.856$$

$$\Delta P_4'' = \frac{3.62 \Sigma K f g^2}{d^4} = \frac{(3.62)(17.905)(0.0322)(3.267)^2}{(4.026)^4} = .08478 \text{ PSI} = .017261 \text{ IN Hg}$$

• FOR 2" PIPE:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(0.019)(297)(12)}{2.067} = 32.760$$

$$\Sigma K = 32.760 + 3.192 = 35.952$$

$$K(\text{ELBOW}) = \text{QTY } 14 f = (12)(14)(0.019) = 3.192$$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 6 of 10

Client B F W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYS. Originated By S.D. Eklund Date 10/20/99

PRESSURE DROP ANALYSIS Checked By B.E. Bui Date 5/1/00

Location PFP COMPLEX, 200W

Revised By

Date

$$\Delta P_2'' = \frac{3.62 \text{ EK} \rho g^2}{d^4} = \frac{(3.62)(35.92)(.0322)(3.267)^2}{(2.067)^4} = 2.4503 \text{ PSI} = 4.98844 \text{ IN Hg}$$

OPTION #2 SUMMARY

- * IF NEW PIPING IS 6" INHERENT $\Delta P = .02121 \text{ IN Hg}$
- IF NEW PIPING IS 4" INHERENT $\Delta P = .17261 \text{ IN Hg}$
- ★ IF NEW PIPING IS 2" INHERENT $\Delta P = 4.98844 \text{ IN Hg}$

FILTER $\Delta P = .29368 \text{ IN Hg}$ (AS BEFORE)

- * BEST CASE TOTAL = $.02121 + .29368 = .31489 \text{ IN Hg}$
- ★ WORST CASE TOTAL = $4.98844 + .29368 = 5.28212 \text{ IN Hg}$

OPTION #3

THE INTENT OF OPTION #3 IS SIMILAR TO THAT OF OPTION #1, TO UTILIZE ONE OR ALL OF THE EXISTING 2" PIPELINES BETWEEN 236-2 AND 291-2, THIS CALCULATION IS SIMILAR TO OPTION #1 WITH THE EXCEPTION THAT THE FOLLOWING NEW PIPE AND FITTINGS ARE EMPLOYED → 136 FT PIPE
FIND NEW EK AND ΔP FOR VARIOUS PIPE SIZES:

- FOR NEW 6" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.015)(136)(12)}{6.065} = 4.036$$

$$K(\text{TEE}) = 60f = (60)(.015) = .9$$

$$K(90^\circ) = 47.14f = (9)(14)(.015) = 1.89$$

$$K(45^\circ) = 47.15f = (2)(15)(.015) = .45$$

(ASSUMED MITRE BEND)

$$\Sigma K = 4.036 + 1.89 + .45 + .9 = 7.276$$

- (9) 90° ELBOWS
- (2) 45° ELBOWS
- (1) TEE, BRANCH FLOW

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 7 of 10

Client B E W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-B/291-Z VACUUM PUMP SYS.

Originated By S.D. Egan

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By BE Bullock

Date 5/1/00

Location PFP COMPLEX, 200W

Revised By

Date

$$\Delta P_6'' = \frac{3.62 \text{ EKFg}^2}{d^4} = \frac{(3.62)(7.276)(.0322)(3.267)^2}{(6.065)^4} = .00669 \text{ PSI} = .01361 \text{ IN Hg}$$

- FOR NEW 4" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.017)(136)(12)}{4.026} = 6.890$$

$$K(90^\circ) = QTY 14f = (9)(14)(.017) = 2.142$$

$$K(45^\circ) = QTY 15f = (2)(15)(.017) = .51$$

$$K(\text{TEE}) = 60f = (60)(.017) = 1.02$$

$$\Sigma K = 6.890 + 2.142 + .51 + 1.02 = 10.562$$

$$\Delta P_4'' = \frac{3.62 \text{ EKFg}^2}{d^4} = \frac{(3.62)(10.562)(.0322)(3.267)^2}{(4.026)^4} = .05001 \text{ PSI} = .10182 \text{ IN Hg}$$

- FOR NEW 2" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.019)(136)(12)}{2.067} = 15.0$$

$$K(90^\circ) = QTY 14f = (9)(14)(.019) = 2.394$$

$$K(45^\circ) = QTY 15f = (2)(15)(.019) = .57$$

$$K(\text{TEE}) = 60f = (60)(.019) = 1.14$$

$$\Sigma K = 15 + 2.394 + .57 + 1.14 = 19.104$$

$$\Delta P_2'' = \frac{3.62 \text{ EKFg}^2}{d^4} = \frac{(3.62)(19.104)(.0322)(3.267)^2}{(2.067)^4} = 1.30204 \text{ PSI} = 2.65072 \text{ IN Hg}$$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 8 of 10

Client B & W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-Z/291-Z VACUUM PUMP SYS. Originated By S. D. Egan

Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By BE Bullock

Date 5/1/00

Location PFP COMPLEX, 200W

Revised By

Date

- FOR EXISTING 2" PIPELINES, COMPONENTS AND FLOW DO NOT CHANGE TO THAT ANALYZED IN OPTION #1, $\therefore$ ALL COMBINATIONS SAME AS OPTION #1.

OPTION #3 SUMMARY

- * IF NEW PIPING IS 6", INHERENT $\Delta P = .01361$ IN Hg
- IF NEW PIPING IS 4", INHERENT $\Delta P = .10182$ IN Hg
- ★ IF NEW PIPING IS 2", INHERENT $\Delta P = 2.65072$ IN Hg
- * IF (3) EXISTING 2" LINES ARE EMPLOYED, INHERENT $\Delta P = .29958$ IN Hg
- IF (2) EXISTING 2" LINES ARE EMPLOYED, INHERENT $\Delta P = .67405$ IN Hg
- ★ IF (1) EXISTING 2" LINE IS EMPLOYED, INHERENT $\Delta P = 2.69622$ IN Hg

FILTER $\Delta P = .29368$ IN Hg (AS BEFORE)* BEST CASE TOTAL = $.01361 + .29958 + .29368 = .60687$ IN Hg★ WORST CASE TOTAL = $2.65072 + 2.69622 + .29368 = 5.64062$ IN HgOPTION #4

LIKE OPTION #2, OPTION #4 EMPLOYS ALL NEW PIPE AND FITTINGS.

DETERMINE NEW ΣK AND ΔP FOR PIPE SIZES 6", 4" & 2". NEW

COMPONENTS INCLUDE: 289 FT PIPE, (12) 90° ELBOWS, (2) 45° ELBOWS & (1) TEE

- FOR NEW 6" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.015)(289)(12)}{6.065} = 8.577 \quad K(\text{TEE}) = 60f = (60)(.015) = .9$$

$$K(90^\circ) = \text{QTY 14 } f = (12)(14)(.015) = 2.52$$

$$K(45^\circ) = \text{QTY 15 } f = (2)(15)(.015) = .45$$

$$\Sigma K = 8.577 + 2.52 + .45 + .9 = 12.447$$

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DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 9 of 10

Client B. F. W. HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYSTEM Originated By S.D. Egan Date 10/20/99

PRESSURE DROP ANALYSIS Checked By BEB Date 5/1/00

Location PFP COMPLEX, ZOOM

Revised By Date

$$\Delta P_6'' = \frac{3.62 \sum K f_8^2}{d^4} = \frac{(3.62)(12.447)(.0322)(3.267)^2}{(6.065)^4} = .0114 \text{ PSI} = .02329 \text{ IN Hg}$$

- FOR NEW 4" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.017)(289)(12)}{4.026} = 14.643$$

$$K(90^\circ) = \text{QTY } 14 \text{ f} = (12)(14)(.017) = 2.856$$

$$K(45^\circ) = \text{QTY } 15 \text{ f} = (2)(15)(.017) = .51$$

$$K(\text{TEE}) = 60 \text{ f} = (60)(.017) = 1.02$$

$$\sum K = 14.643 + 2.856 + .51 + 1.02 = 19.029$$

$$\Delta P_4'' = \frac{3.62 \sum K f_8^2}{d^4} = \frac{(3.62)(19.029)(.0322)(3.267)^2}{(4.026)^4} = .0901 \text{ PSI} = .18345 \text{ IN Hg}$$

- FOR NEW 2" PIPING:

$$K(\text{PIPE}) = \frac{fL}{D} = \frac{(.019)(289)(12)}{2.067} = 31.878$$

$$K(90^\circ) = \text{QTY } 14 \text{ f} = (12)(14)(.019) = 3.192$$

$$K(45^\circ) = \text{QTY } 15 \text{ f} = (2)(15)(.019) = .57$$

$$K(\text{TEE}) = 60 \text{ f} = (60)(.019) = 1.14$$

$$\sum K = 31.878 + 3.192 + .57 + 1.14 = 36.78$$

$$\Delta P_2'' = \frac{3.62 \sum K f_8^2}{d^4} = \frac{(3.62)(36.78)(.0322)(3.267)^2}{(2.067)^4} = 2.5067 \text{ PSI} = 5.10333 \text{ IN Hg}$$

FLUOR ~~DANIEL NORTHWEST~~

DESIGN ANALYSIS

Calc. No. 5204-22-M-002

Revision 0

Page No. 10 of 10

Client B F W HANFORD

Contract/Job No. CONTRACT 5204, RELEASE 22

Subject 236-2/291-2 VACUUM PUMP SYSTEM Originated By S.D. Egan Date 10/20/99

PRESSURE DROP ANALYSIS

Checked By B.E. Buhich Date 5/1/00

Location PFY COMPLEX, 200 W

Revised By Date

OPTION #4 SUMMARY

- * IF NEW PIPING IS 6", INHERENT $\Delta P = .02329$ IN Hg
- IF NEW PIPING IS 4", INHERENT $\Delta P = .18345$ IN Hg
- ★ IF NEW PIPING IS 2", INHERENT $\Delta P = 5.10333$ IN Hg

FILTER $\Delta P = .29368$ IN Hg (AS BEFORE)* BEST CASE TOTAL = $.02329 + .29368 = .31697$ IN Hg★ WORST CASE TOTAL = $5.10333 + .29368 = 5.39701$ IN HgCHECK COMPRESSIBILITY:

THE ABOVE CALCULATIONS DID NOT CHECK FOR THE NEED TO CORRECT FOR EXPANSION FACTOR (REF CRANE FOR COMPRESSIBLE FLOW). ALL CONCLUSIONS MUST BE CORRECTED WITH EXPANSION FACTOR "Y" IF $\Delta P > 10\% P_1$... CHECK TO SEE IF THIS IS REQUIRED:

$$P_1 = 17 \text{ IN Hg VACUUM} = 6.3 \text{ PSIA} \quad \therefore 10\% P_1 \Rightarrow .63 \text{ PSIA} = 1.28257 \text{ IN Hg}$$

OPTION #1 BEST CASE TOTAL = $.59929$ IN Hg $\therefore < 1.28257$ OK
 WORSTCASE TOTAL = 4.08091 IN Hg $\therefore > 1.28257$ NO!

BY OBSERVATION OF OTHER TOTALS, IT IS READLY SEEN THAT THE WORST CASE CONDITIONS FOR EACH OPTION WOULD BE GREATER THAN 10% OF P_1 AND WOULD REQUIRE CORRECTION. THIS WILL BE ACCOUNTED FOR IN ADDITIONAL ANALYSIS IF THE CUSTOMER CONSIDERS SUCH AN OPTION.

CONCLUSION SEE EACH OPTION SUMMARY FOR APPLICABLE ΔP 'S.
 USE THIS INFORMATION FOR FINAL PIPE SELECTION.

PLOT PLAN
OPTION #2

10/00/99

236-Z/291-Z VACUUM SYSTEM EVAL.

PLOT PLAN #3 OPTION #3	10/20/99 SKE
	236-Z/291-Z VACUUM SYSTEM EVAL.

PLOT PLAN OPTION #4

SPE 10/20/99

236-Z/291-Z VACUUM SYSTEM EVAL.